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MODELING OF INDIVIDUAL TELEROENTGENOMETRIC INDICATORS USING THE COGS METHOD IN UKRAINIAN YOUNG MEN WITH A WIDE FACE TYPE

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Annotation. *Cephalometric techniques for the analysis of lateral teleroentgenograms, for successful use in orthodontist practice, require a preliminary clinical study, which should include as many healthy individuals as possible from the local population for which this technique will be applied. The purpose of the study is to build and analyze regression models of radio-radiographic parameters used in COGS-methodology in Ukrainian young men with an orthognathic bite with a wide face type. 22 Ukrainian young men with an orthognathic bite and a wide face type underwent a cephalometric study using the COGS method. For the correct modeling of cephalometric characteristics, the division of teleroentgenometric indicators into three groups proposed by M. O. Dmitriev (2016, 2017) was used: the first group is the metric characteristics of the skull, which usually do not change during surgical and orthodontic treatment; the second group - indicators of the maxillofacial system, which can be used to change the width, length, angles and position of the upper and lower jaws with the help of orthognathic surgery; the third group - indicators that actually characterize the position of each individual tooth relative to each other, cranial structures and the profile of the soft tissues of the face. Construction of regression models of cephalometric indicators according to the COGS method was carried out in the "Statistica 6.0" license package. It was established that only 4 reliable regression models of teleroentgenometric indicators with a coefficient of determination greater than 0.6 were built using the COGS method for Ukrainian young men with a wide face, which were included in the second and third groups depending on the indicators of the first group (R?= from 0.626 to 0.780), as well as 11 reliable models of indicators were built out of 19 possible, which were included in the third group depending on the indicators of the first and second groups (R^2= from 0.626 to 0.970). The analysis of the constructed regression equations showed that most often the models of indicators that were included in the second and third groups, depending on the indicators of the first group, include the value of the distances P-PTV (17.64 %) and N-Se (11.76 %) and the value of the angles H (17.64 %) and N-S-Ba (11.76 %); and to the indicator models that were included in the third group depending on the indicators of the first and second groups - the value of the distances ANS-Me (15.00 %), A-B and N-Pog (7.50 % each) and the value of the angles Ar-Go-Gn, H and N-A -Pog (7.50 % each). Further research will make it possible to develop a computer program that will enable dentists to automatically calculate individual normative teleroentgenometric indicators.*
Keywords: *regression models, teleradiography, cephalometry, COGS-method, facial types, orthognathic bite, young men.*

Intriduction

A person's face is a key element for social perception in all spheres of activity. A more attractive face is associated with a better social role of the individual. In this regard, one of the key tasks of modern medicine has become the creation and improvement of existing methods of facial aesthetics, in particular, and smiles.

Indeed, research data indicate that the average face type (mesofacial) is the most attractive to different groups of respondents (specialists, dentists and ordinary citizens, $p<0.01$ in all cases) compared to dolichofacial and brachyfacial types [3]. It should be noted that in this study the smiles of the persons were hidden and only the face was evaluated. What are the data on the aesthetics of a smile?

The aesthetics of a smile is inextricably linked to the face as a whole. Ward D. H. in his research established that the most proportional and harmonious smile is created using a width/length ratio of the maxillary central incisor of 78 % [21].

At the same time, pathology of the maxillofacial system is extremely common. Thus, in adolescence, the frequency of malocclusion steadily increases and increased from 11 % to 93 % according to Slovenian scientists [13]. Data from India indicate that the frequency of such pathology among schoolchildren is about 33 % [18].

One of the tools for achieving an aesthetically attractive face and smile is a cephalometric analysis. This is especially true in cases of facial reconstructive surgery. This is possible due to the fact that the cephalometric method is based on the fact that there is a balance of various elements of the face (skeletal and soft tissue) and teeth. In addition, these indicators are highly individual for different ethnic groups, genders and other parameters that must be taken into account [7]. In particular, one of these parameters is age. Using the example of the horizontal condylar angle, changes in the indicator in different age groups and even asymmetry in its parameters on the left and right are shown [17].

There are still ongoing discussions about the feasibility of using 2D lateral cephalometric analysis - there are works that simultaneously indicate its irreplaceability and feasibility, as well as one that does not have a sufficient impact on treatment planning [12]. However, like any method, cephalometric analysis requires sufficient

qualification, experience and skill in use, because the identification of some points, angles and lines used in different types of analysis is complicated [14].

Does cephalometric analysis help create an attractive face? Data from 108 clinical cases evaluated by Chinese orthodontists showed that cephalometric indicators are highly correlated with photographic assessment of facial attractiveness. This especially applies to indicators such as incisal angle, profile angle, L1/MP°, L1-NBmm, Z angle [22].

Thus, there is a need to conduct research on the identification of normative cephalometric indicators for the Ukrainian population, taking into account as many parameters as possible.

The purpose of our study is to build and analyze regression models of teleroentgenometric indicators used in the COGS-method in Ukrainian young men with an orthognathic bite with a wide face type.

Materials and methods

22 Ukrainian young men (YM) with a physiological bite (as close as possible to orthognathic, later orthognathic) with a wide face (face type was determined using Garson's morphological index [15]) underwent a cephalometric study using the COGS method ("Cephalometrics for orthognathic surgery" [5]) for which the software OnyxCeph^{3}™, version 3DPro, of the company Image Instruments GmbH, Germany, was used (software license №URSQ-1799 registered to Dmitriev M. O.). Primary teleradiograms (obtained using a Veraviewepocs 3D Morita dental cone-beam tomograph) were taken from the database of the Research Center and the Department of Pediatric Dentistry of the National Pirogov Memorial Medical University, Vinnytsia (all young men applied to the private dental clinic "Vinintermed" for a diagnostic examination, and who previously underwent a dental examination and gave voluntary consent for the further use of the obtained results in our study).

Committee on Bioethics of National Pirogov Memorial Medical University, Vinnytsya (protocol № 8 From 30.09.2021) found that the studies do not contradict the basic bioethical standards of the Declaration of Helsinki, the Council of Europe Convention on Human Rights and Biomedicine (1977), the relevant WHO regulations and laws of Ukraine.

For the correct modeling of a large array of metric characteristics, we used the distribution of teleroentgenometric indicators into three groups proposed by M. O. Dmitriev [8, 9, 10]:

- *the first group* - metric characteristics of the skull, which usually do not change during surgical and orthodontic treatment. Since only 2 cranial parameters (**Ar-Pt** distance (mm) and **Pt-N** distance (mm)) belong to the first group in the COGS methodology, for a more informative study we used the most common measurements of basic cranial parameters proposed by other authors: Schwartz

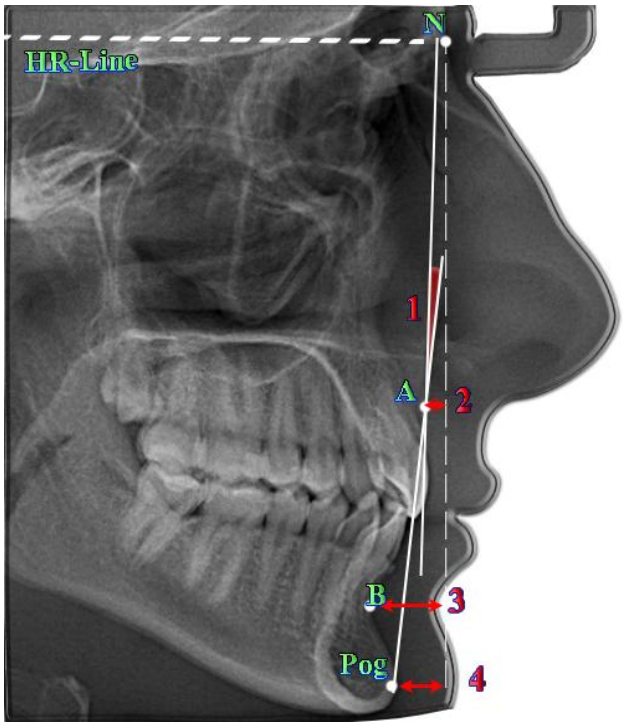

Fig. 1. The main cephalometric points and measurements according to the COGS method, included in the second group of indicators: 1 - angle **N-A-Pog**; 2 - distance **N-A**; 3 - distance **N-B**; 4 - distance **N-Pog**.

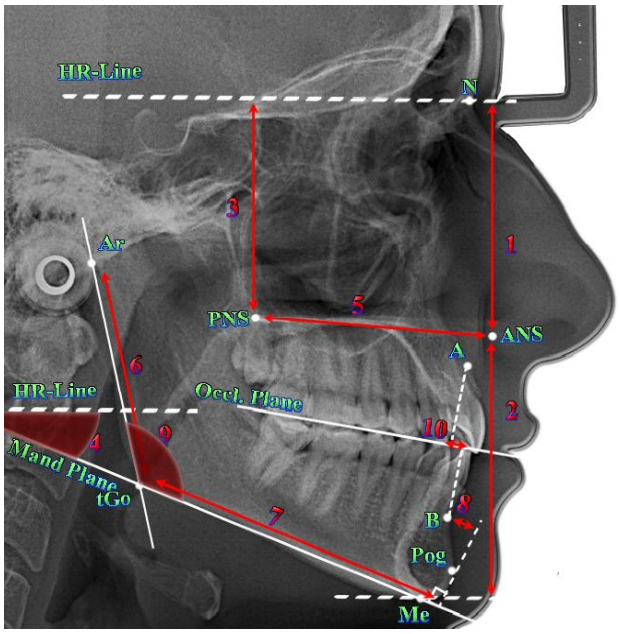

Fig. 2. The main cephalometric points and measurements according to the COGS method, included in the second group of indicators: 1 - distance **N-ANS**; 2 - distance **ANS-Me**; 3 - distance **PNS-N**; 4 - angle **MP-HP**; 5 - distance **ANS-PNS**; 6 - distance **Ar-Go**; 7 - distance **Go-Pog**; 8 - distance **B-Pog**; 9 - angle **Ar-Go-Gn**; 10 - distance **A-B**.

N-Se distance (mm), Roth-Jarabak **N-S** distance (mm), Ricketts **N-CC** distance (mm), Steiner **S-E** distance (mm); **S-Ar** distance according to Roth-Jarabak (mm), **P-PTV**

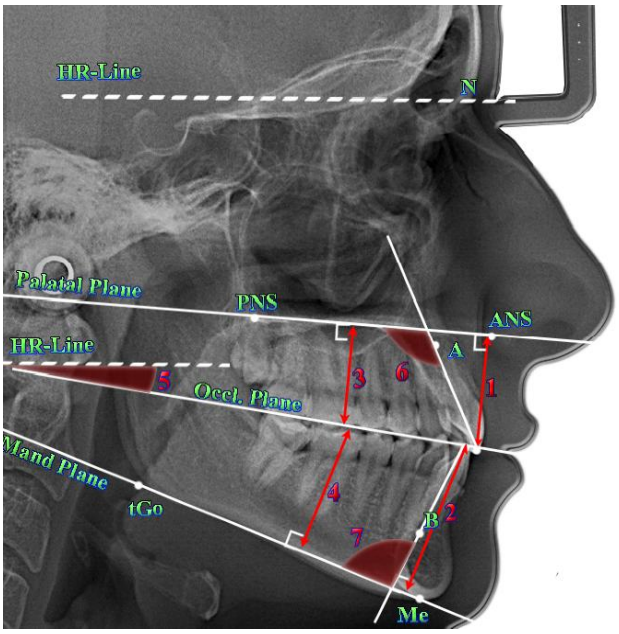

Fig. 3. The main cephalometric points and measurements according to the COGS method, included in the third group of indicators: 1 - distance **1u-NF**; 2 - distance **1l-MP**; 3 - distance **6u-NF**; 4 - distance **6l-MP**; 5 - angle **OP-HP**; 6 - angle **Max1-N**F; 7 - angle **Mand1-MP**.

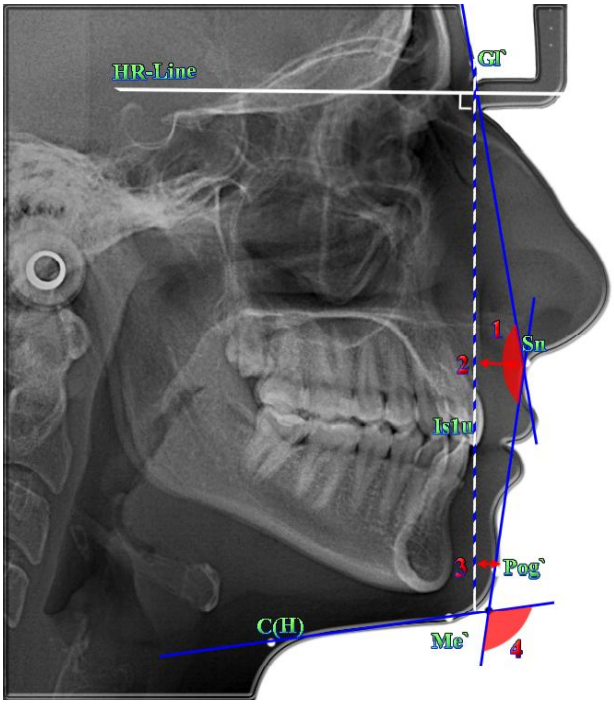

Fig. 4. Indicators of soft facial profile structures according to the COGS method, which characterize the shape of the facial profile and are included in the third group of indicators: 1 - angle **Gl'-Sn-Pog'**; 2 - distance **Gl'-Sn**; 3 - distance **Gl'-Pog'**; 4 - angle **Sn-Gn'-C**.

distance according to Ricketts (mm), **S-Ar'** distance according to Roth-Jarabak (mm), angle **H** according to Schwartz (°), **POr-NBa** angle according to Ricketts (°), angle **N-S-Ba** by Bjork (°). angle **N-S-Ar** according to Bjork (°),

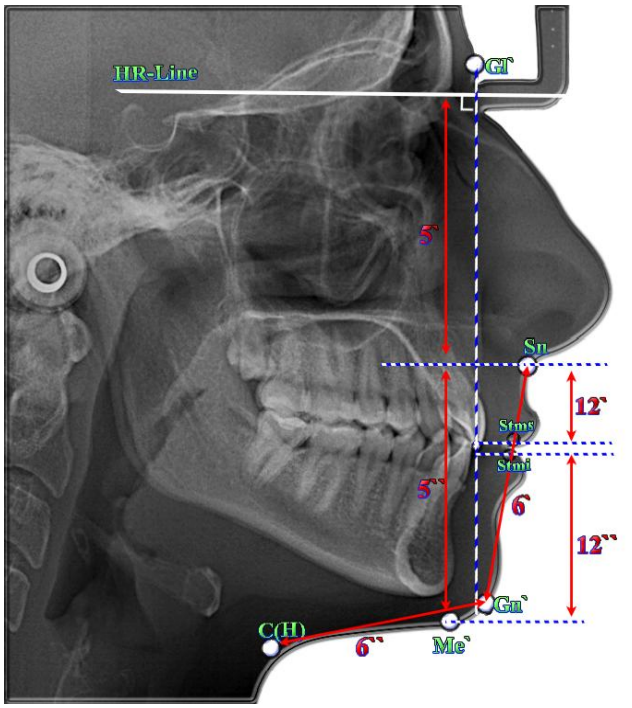

Fig. 5. Calculated indicators of soft facial profile structures according to the COGS method, which are included in the third group of indicators and characterize the *shape of the facial profile*: 5 - ratio **Gl'-Sn(5')/Sn-Me'(5'')**; 6 - ratio **Sn-Gn'(6')/C-Gn'(6'')**; and the *position and shape of the lips*: 12 - ratio **Sn-Stms(12')/Stmi-Me'(12'')**.

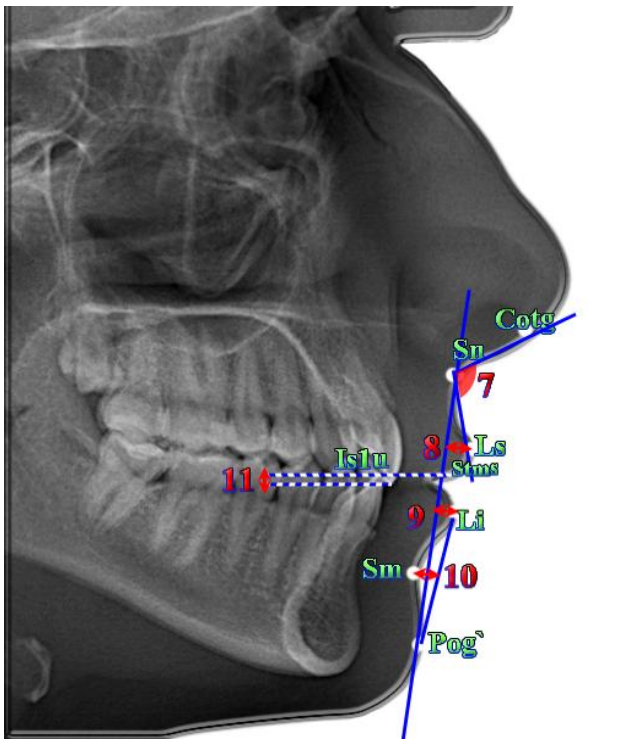

Fig. 6. Indicators of the structures of the soft profile of the face according to the COGS method, which characterize the position and shape of the lips and are included in the third group of indicators: 7 - angle **Cotg-Sn-Ls**; 8 - distance **Ls-(Sn-Pog')**; 9 - distance **Li-(Sn-Pog')**; 10 - distance **Sm-(Li-Pog')**; 11 - distance **Stms-I**.

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ratio **N-S:S-Ar'** according to Bjork;

- *the second group* - indicators of the maxillofacial system, which can be used to change the width, length, angles and position of the upper and lower jaws with the help of orthognathic surgery (Figs. 1, 2);
- *the third group* - indicators that actually characterize the position of each individual tooth relative to each other, cranial structures (Fig. 3) and the profile of the soft tissues of the face (Figs. 4, 5, 6).

In the "Statistica 6.0" license package, the method of stepwise regression analysis is used to build models of cephalometric indicators according to the COGS method.

Results. Discussion

In Ukrainian young men with an orthognathic bite with a wide facial type, 4 reliable regression equations of teleroentgenometric indicators were constructed from 33 possible according to the COGS method with a coefficient of determination greater than 0.6, which were included in the second and third groups depending on the indicators of the first group:

distance value N-B=75.05 - 0.818 x H - 1.856 x S-E - 0.908 x P-PTV (R^2=0.639, $F_{(3.18)}$=10.63, p<0.001, Std.Error of estimate=4.427);

distance value N-Pog=245.3 - 1.892 x P-PTV - 0.704 x Por-NBa + 2.086 x N-Se - 0.864 x N-S-Ba - 41.41 x N-S:S-Ar' - 9.380 x S-Ar' (R^2=0.780, $F_{(6.15)}$=8.87, p<0.001, Std.Error of estimate=4.506);

distance value PNS-N=-29.29 + 0.524 x N-Se + 0.599?S-Ar + 0.252 x H (R^2=0.713, $F_{(3.18)}$=14.93, p<0.001, Std.Error of estimate=1.521);

distance value Sm-(Li-Pog')=-2.974 - 0.286 x Pt-N + 0.203 x P-PTV + 0.124 x N-S-Ba + 0.184 x N-S - 0.090 x H (R^2=0.626, $F_{(5.16)}$=5.37, p<0.01, Std.Error of estimate=0.659);

where, here and in the following equations, R^2 - coefficient of determination; $F_{(!)}$=! - critical (!) and obtained $_{(!)}$ Fisher's test value; p - confidence level; Std.Error of estimate - standard error of estimate.

Coefficients of determination of the regression equations of the *distance values N-A, N-ANS, ANS-Me, ANS-PNS, Ar-Go, Go-Pog, B-Pog, A-B, 1u-NF, 1l-MP, 6u-NF, 6l-MP, Gl'-Sn, Gl'-Pog', Ls-(Sn-Pog') and Stms-I, angles MP-HP, Ar-Go-Gn, OP-HP, Max1-NF, Mand1-MP and Sn-Gn'-C and the values of the ratios Gl'-Sn/Sn-Me', Sn-Gn'/C-Gn' and Sn-Stms/Stmi-Me'* in young men with a wide face are from 0.093 to 0.598 and therefore have no practical significance in dental practice. The regression equations of the *angles N-A-Pog, Gl'-Sn-Pog', Cotg-Sn-Ls and the distance Li-(Sn-Pog')* are not constructed at all.

Thus, only 4 reliable regression models of teleroentgenometric indicators with a coefficient of determination greater than 0.6 were built using the COGS method for Ukrainian young men with a wide face type, which were included in the second and third groups depending on the indicators of the first group (R^2= from 0.626 to 0.780). Most often, these models include: the value of the P-PTV (17.64 %) and N-Se (11.76 %) distances and the value of the H (17.64 %) and N-S-Ba (11.76 %) angles.

Out of 19 possible, in young men with an orthognathic bite with a wide face, 11 reliable regression equations of teleroentgenometric indicators were constructed using the COGS method with a coefficient of determination greater than 0.6, which were included in the third group depending on the indicators of the first and second groups:

distance value 1u-NF=-1.730 + 0.456 x ANS-Me - 0.138 x N-Pog (R^2=0.748, $F_{(2.19)}$=28.21, p<0.001, Std.Error of estimate=1.389);

distance value 1l-MP=36.61 + 0.586 x ANS-Me + 0.667 x A-B - 0.393 x ANS-PNS - 0.131 x H (R^2=0.822, $F_{(4.17)}$=19.59, p<0.001, Std.Error of estimate=1.019);

distance value 6u-NF=-7.757 + 0.319 x ANS-Me - 0.124 x N-A-Pog + 0.200 x ANS-PNS (R^2=0.627, $F_{(3.18)}$=10.09, p<0.001, Std.Error of estimate=1.234);

distance value 6l-MP=-10.01 + 0.489 x ANS-Me - 0.751 x B-Pog + 0.150 x N-S-Ar - 0.103 x MP-HP (R^2=0.799, $F_{(4.17)}$=16.88, p<0.001, Std.Error of estimate=1.094);

angle value OP-HP=44.01 + 0.961 x MP-HP - 0.312 x Ar-Go-Gn - 0.379 x PNS-N (R^2=0.943, $F_{(3.18)}$=98.57, p<0.001, Std.Error of estimate=1.409);

angle value Max1-NF=147.7 + 0.590 x N-Pog - 0.597 x Por-NBa - 0.317 x N-A-Pog - 0.245 x Go-Pog (R^2=0.841, $F_{(4.17)}$=22.45, p<0.001, Std.Error of estimate=2.783);

angle value Mand1-MP=94.16 - 0.447 x Ar-Go-Gn + 1.602 x A-B - 0.612 x N-ANS + 1.916 x Ar-Pt+ 6.608 x N-S:S-Ar' (R^2=0.846, $F_{(5.16)}$=17.59, p<0.001, Std.Error of estimate=3.382);

angle value Gl'-Sn-Pog'=78.72 + 0.815 x N-A-Pog - 0.637 x ANS-Me - 0.254 x N-B - 0.290 x H (R^2=0.896, $F_{(4.17)}$=36.56, p<0.001, Std.Error of estimate=2.161);

distance value Gl'-Sn=25.04 + 1.060 x N-A - 0.243 x ANS-Me + 0.225 x S-Ar - 0.088 x Ar-Go-Gn (R^2=0.947, $F_{(4.17)}$=76.49, p<0.001, Std.Error of estimate=1.158);

distance value Gl'-Pog'=1.704 + 1.148 x N-Pog + 0.335 x A-B (R^2=0.970, $F_{(2.19)}$=303.3, p<0.001, Std.Error of estimate=1.704);

distance value Sm-(Li-Pog')=-2.974 - 0.286 x Pt-N + 0.203 x P-PTV + 0.124 x N-S-Ba + 0.184 x N-S - 0.090 x H (R^2=0.626, $F_{(5.16)}$=5.37, p<0.01, Std.Error of estimate=0.659).

Coefficients of determination of the regression equations of the *distances Ls-(Sn-Pog'), Li-(Sn-Pog') and Stms-I, the values of the angles Sn-Gn'-C and Cotg-Sn-Ls and the values of the ratios Gl'-Sn/ Sn-Me', Sn-Gn'/H-Gn' and Sn-Stms/Stmi-Me'* in young men with a wide face are equal to 0.247 to 0.458 and therefore have no practical value in dental practice.

Thus, 11 reliable models of teleroentgenometric indicators with a coefficient of determination greater than 0.6 were built using the COGS method for Ukrainian young men with a wide face type, which were included in the third group depending on the indicators of the first and second groups (R?= from 0.626 to 0.970). Most often, these models include: ANS-Me (15.00 %), A-B (7.50 %) and N-Pog

(7.50 %) distances and Ar-Go-Gn (7.50 %), H (7.50 %) and N-A-Pog (7.50 %) values of the angles.

In the work of Ukrainian scientists, pronounced manifestations of sexual dimorphism were found in the local population for such dimensions as NS, Ar-Go, N-Se, N-CC, P-PTV and S-Ar distances in representatives with different types of faces. For the most part, the indicators were higher in men [11].

Manifestations of sexual dimorphism of cephalometric indicators were revealed in the analysis of data of the population living in the region of Himachal Pradesh (India). Greater values of the nasolabial angle, face length and thickness of soft tissues were found in men [1]. Similar data were obtained in the Uttar Pradesh region (also in India). Compared to men, women had a steeper maxillary occlusal plane, more inclined mandibular incisors, and less protruding lips [20].

Differences with normative parameters were found for the Iranian population according to various cephalometric parameters: Iranians had higher values of anterior lower face height, Sella-Nasion (S-N) length, and ANB angle. Most sizes were larger in men than in women ($p<0.05$) [2].

Compared to Europeans, the Japanese have a less convex profile of the skeleton, a less prominent nose, a more curved chin and a prominent incisor of the lower jaw [4].

Compared to Europeans, Turkish residents have increased facial convexity, larger values of the nasolabial angle and protrusion of the upper lip, smaller values of the angle of the lower part of the face and throat. Turkish women have higher values of the nasolabial angle than men [6].

Representatives of the Maratha ethnic group (India) are characterized by such features as: more beveled maxillary incisors, a less prominent chin, shorter face length, larger values of the nasolabial angle and the thickness of all soft tissues [16].

Also, sexual dimorphism was found among Bulgarians for all cephalometric indicators except for the ANB angle. Greater values were found among men [19].

Conclusion and prospects for further developments

1. In young men with a wide face, 4 reliable regression equations of teleroentgenometric indicators with a coefficient of determination higher than 0.6 were constructed according to the COGS method, which were included in the second and third groups depending on the indicators of the first group (R^2= from 0.626 to 0.780) and 11 regression equations of indicators, which were included in the third group depending on the indicators of the first and second groups (R^2= from 0.626 to 0.970).

2. Among the teleroentgenometric indicators of the first group, which were included in the regression equations of the indicators of the second and third groups according to the COGS method, the value of the P-PTV distance and the H angle (17.64 % each) and the value of the N-Se distance and the N-S-Ba angle are most often included (11.76 % each).

3. Among the teleroentgenometric indicators of the first and second groups that were included in the models of the indicators of the third group according to the COGS method, the values of the distances ANS-Me (15.00 %), A-B and N-Pog (7.50 % each) and the values of the angles Ar-Go-Gn, H and N-A-Pog (7.50 % each).

The regression models of teleroentgenometric indicators used in the COGS method in young men with an orthognathic bite with a wide facial type that we built will allow us to develop a computer program that will enable dentists to automatically calculate individual normative indicators.

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МОДЕЛЮВАННЯ ІНДИВІДУАЛЬНИХ ТЕЛЕРЕНТГЕНОМЕТРИЧНИХ ПОКАЗНИКІВ ЗА COGS-МЕТОДОМ В УКРАЇНСЬКИХ ЮНАКІВ ІЗ ШИРОКИМ ТИПОМ ОБЛИЧЧЯ

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Анотація. *Цефалометричні методики аналізу бокових телерентгенограм для успішного застосування в практиці ортодонта вимагають виконання попереднього клінічного дослідження, що має включати в себе максимально здорових осіб з місцевої популяції, для якої цю методику буде застосовано. Мета дослідження - побудова та аналіз регресійних моделей телерентгенометричних показників, що використовуються в COGS-методиці в українських юнаків із ортогнатичним прикусом із широким типом обличчя. 22 українським юнакам із ортогнатичним прикусом і широким типом обличчя проведено цефалометричне дослідження за COGS-методом. Для коректного моделювання цефалометричних характеристик використано розподіл телерентгенометричних показників на три групи, запропонований Дмітрієвим М. О. (2016, 2017): перша група - метричні характеристики черепа, які зазвичай не змінюються в процесі хірургічного та ортодонтичного лікування; друга група - показники зубощелепної системи, яким за допомогою ортогнатичної хірургії можливо змінювати ширину, довжину, кути та положення верхньої та нижньої щелеп; третя група - показники, які власне характеризують положення кожного окремого зуба відносно один одного, черепних структур та профілю м'яких тканин обличчя. Побудова регресійних моделей цефалометричних показників за COGS-методом проведена в ліцензійному пакеті "Statistica 6.0". Встановлено, що в українських юнаків із широким обличчям за COGS-методом із 33 можливих побудовано лише 4 достовірних регресійних моделі телерентгенометричних показників з коефіцієнтом детермінації понад 0,6, які увійшли до другої та третьої груп залежно від показників першої групи (R?= від 0,626 до 0,780), а також із 19 можливих побудовано 11 достовірних моделей показників, які увійшли до третьої групи залежно від показників першої та другої груп (R?= від 0,626 до 0,970). Аналіз побудованих регресійних рівнянь показав, що найбільш часто до моделей показників, які увійшли до другої та третьої груп залежно від показників першої групи, входять величина відстаней P-PTV (17,64%) і N-Se (11,76%) та величина кутів H (17,64%) і N-S-Ba (11,76%); а до моделей показників, які увійшли до третьої групи залежно від показників першої та другої груп, - величина відстаней ANS-Me (15,00%), A-B і N-Pog (по 7,50%) та величина кутів Ar-Go-Gn, H і N-A-Pog (по 7,50%). Подальші дослідження дозволять розробити комп'ютерну програму, яка дасть можливість лікарям-стоматологам автоматично вираховувати індивідуальні нормативні телерентгенометричні показники.*

Ключові слова: *регресійні моделі, телерентгенографія, цефалометрія, COGS-метод, типи обличчя, ортогнатичний прикус, юнаки.*